# Use of Unknown Input Observer for Actuator Fault Detection in ANCL Helicopter

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## ABSTRACT

The interest in unmanned aerial vehicle (UAV) systems with helicopter-like capabilities for both civil and military application, is becoming well established.  In order to provide safe flight on a helicopter, it is necessary to detect its faults and make emergency landings at the appropriate time. The  goal in this paper  is detection of actuator fault  in ANCL helicopter. For this purpous, two unknown input  observer is designed. The first observer  is used to detect faults in longitudinal and  lateral actuator and the secound  for detect a fault in the pedal actuator. The result show that observer is able to detect and  isolate fault in ANCL actuators.

**Keywords:** ANCL helicopter, fault detection, unknown input observer.

Nomenclature

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|---|---|---|---|
| $v^B = [u \quad v \quad w]^T$ | Longitudinal ,lateral, and vertical speed in helicopter reference frame | $d_{lon}$ | Cyclic longitudinal control input |
| $\omega^B = [p \quad q \quad r]^T$ | Roll, pitch, and yaw rates in helicopter reference frame | $d_{lat}$ | Cyclic lateral control input |
| $f^B = [X \quad Y \quad Z]^T$ | General external forces acting on the vehicle | $d_{ped}$ | Directional control input |
| $\tau^B = [L \quad M \quad N]^T$ | General external moments acting on the vehicle | $d_{col}$ | Collective control input |
| I | Inertial matrix | $a_1, b_1$ | Longitudinal and lateral rotor flapping angles |
| $\Theta = [\varphi \quad \theta \quad \psi]^T$ | Eular angles | $a_{1f}, b_{1f}$ | Longitudinal and lateral stabilizer flapping angles |

## 1. INTRODUCTION

Small-scale helicopter are increasingly popular platforms for unmanned aerial vehicles (UAVs). The ability of helicopter to take off and land vertically, to perform hover flight as well as cruise flight, and their agility, make them ideal vehicle for a range of applications in a variety of environments[1].
In order to provide safe flight on a helicopter, it is necessary to detect its faults and make emergency landings at the appropriate time. fault detection (FD) approaches can be generally classified into two categories:  model-based and data-based schemes[2]. A model based approach utilizes mathematical model for FD. Four most commonly used techniques are based on (1) state estimation; (2) parameter estimation; (3) parity space; and (4) combination of the first three. One of the best methods for fault  detection is the use of observers. Castillo and Zufiria in [3] use luenberger observer but this observer isn't robust against disturbances and unknown uncertainty. Unknown input observer (UIO) and sliding mode observer( SMO) are robust and better observer for FD.  In [4] a SMO is designed for fault detection in nonlinear system, also this observer is used for FD on helicopter in[5,6]. In [7] is used a UIO observer for this purpous. The goal in this paper is detection of actuator fault in ANCL helicopter. So in the following, we describe the ANCL model first, and we design a PI controller in section (2). In section (3), the UIO observer is designed to detect  faults in actuators. Section (4) includes simulation of the designed observer and Finally, in section (5), the results are mentioned.